IN-SITU BIOREMEDIATION AND ITS APPLICATIONS

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Introduction -

Bioremediation is the process, which abates or cleans up contamination. It is a type of waste management technique which that uses living organisms or their by-products to remove pollutants and contaminants from the environment.

Bioremediation also involves the use of organisms to remove or utilize the pollutants from a polluted area. There are several remedies where contaminated water or solid is purified by chemical treatment, incineration, and burial in a landfill. Bioremediation has no use of toxic chemicals. Microorganisms like bacteria and fungi are the main role player in the process of Bioremediation. Bacteria break down the waste into nutrients and organic matter. Even though this is an efficient process of waste management but bioremediation cannot destroy 100% contaminants. Bacteria can easily digest contaminants like chlorinated pesticides or clean oil spills but microorganisms fail to destroy heavy metals like lead and cadmium. In this article further we will discuss about In-Situ Bioremediation.

In-situ Bioremediation -

This involves treating contaminants directly in the contaminated soil or water without removing them. This approach is more cost-effective and less disruptive than Ex-situ bioremediation. In-situ bioremediation can be further classified into:

Bioaugmentation-

Adding microorganisms to the contaminated site to increase the population and activity of indigenous microorganisms. This technique can be used to enhance the biodegradation of organic pollutants, such as petroleum hydrocarbons and chlorinated solvents. The addition of microorganisms, such as bacteria or fungi, can increase the activity of microorganisms, resulting in faster and more complete degradation of pollutants. In wastewater treatment plants, the biodegradation of contaminants or pollutants by harnessing microorganisms present in activated sludge is one of the most important strategies to remove organic contaminants from wastewater.

Applications of Bioaugmentation

-Chlorinated and Fluorinated Compounds Removal

Halogenated compounds are used in various applications, such as plastic components, lubricants, adhesives, solvents, degreasing agents, pesticides, fungicides, and worldwide, the total amount of chlorinated solvents used as 764,000 metric tons.

Such as extensive use in both industry and homes leads to contamination of wastewater, and bioaugmentation has proven to be an important strategy for their elimination.

-Lignin Removal

The pulp and paper industry generates large volume of wastewater with a high lignin content, Known as black liquor. Selection and addition of lignin-biodegrading microorganisms into waste water provides an attractive strategy to remove specific pollutants originated from black liquor.

-Quinoline and Pyridine

Quinolines and pyridines are N-heterocyclic aromatic compounds commonly found in industrial and pharmaceutical raw materials and used as solvents for dyes, paints, and wood treatment chemicals, which leads to their presence in industrial wastewater. They persist in the environment because of their low biodegradability, and they are carcinogenic. A report showed the enhancement of quinoline biodegradation by using Bacillus sp. Isolated from soil in a 250mL batch reactor, filled with petroleum refinery wastewater.

-Synthetic Dyes

Synthetic Dyes, which primarily consist of azo- and anthraquinone-based molecules, are extensively used in textile and cosmetics, and over 7 x 105 tons of dyes are produced per year. It is estimated that 2%-10% contaminate the environment, primarily through industrial waste water.

-Cyanides

The industrial wastewater must be treated before being discharged into the environment. To enhance the efficiency of the biological removal of cyanides, bioaugmentation was applied to a full-scale coke wastewater treatment process by using cyanide-degrading yeast Cryptococcus humicolus and unidentified cyanide-degrading microorganisms in waste water that contained ferric cyanide.

-Bio stimulation

It involves providing nutrients or other substances to stimulate the growth and activity of indigenous microorganisms. In this technique the biodegradation of organic pollutants, such as petroleum hydrocarbons and chlorinated solvents are enhanced. The addition of nutrients, such as nitrogen and phosphorus, can increase the activity of microorganisms, resulting in faster and more complete degradation of pollutants.

Applications of Bio stimulation

The major contaminants that can be successfully remediated through biostimulation are petroleum hydrocarbons, sulphate and polyester polyurethanes.

- Phytoremediation

Using plants to remove or detoxify contaminants from the environment. To remediate a wide range of contaminants, heavy metals, organic pollutants, and radioactive substances. Plants can absorb, store, and/or metabolize contaminants in the soil or water, resulting in the breakdown or transformation of contaminants into less harmful substances.

Applications of Phytoremediation

-Heavy Metal Removal

It can affect soil and water quality, plant and animal growth, and human health. Metals have metallic properties such as density, conductivity. This is where phytoremediation and its application come in. Most of the plant species can immobilize metals.

-Removal of Fly Ash

Thermal power plants produce a large amount of coal fly ash (600 million (tons/year). The disposal of fly ash causes important health and environmental hazards. Thus, its disposal has become a major worldwide concern. Phytoremediation is a practical, and cheap way fornrevegetation of fly ash dump sites. A study has shown that (Vetiverianzizanioides) grass can remediate fly ash dump sites.

Besides Phytostabilization of heavy metals, Vetiveria zizanioides also reduces genotoxicity.

-Phytoremediation of landfills

Landfilling offers an inexpensive means of waste disposal. But if not managed it can cause serious contamination to the environment. Phytoremediation has proven to be a promising technique. Phytoremediation technique use trees to remediate the contaminants on landfills sites.

-Phytoextraction

It is uses to collect metals. It involves root uptake of metals and their migration from the xylem to the shoots and leaves. These are then harvested and removed from the site. Sunflower (Helianthus annuus) has been the most used species for phytoextraction. Its growth and high potential are good for the
remediation of toxic contaminants.

-Phyto-stabilization

This approach uses plant roof to restrict contaminant in the soil through adsorption. The main purpose of Phyto stabilization is to detain the contaminants in the rhizosphere. It is a cost effective approach for stabilizing and reducing the bio-availability of contaminants.

-Phytodegradation

This involves microorganisms in association with plant metabolic to detoxify pollutants such as: Herbicides, Chlorinated solvents, Insecticides, Inorganic pollutants. This approach uses plants to absorb and then break down the pollutants. The pollutants convert into inert substances that release into the air.

-Phytovolatilization

This is used to absorb contaminants fromb polluted sites. It converts them into volatile compounds. Phytovolatilization uses plants for contaminants like mercury (Hg).

-Rhizofiltration

It combines phytoextraction and Phyto stabilization. This procedure involves absorption, concentration, and participation of contaminants in wastewater, surface water. This process uses grown terrestrial plants, such as mustard and sunflower. These remove Cu, Cd, Cr, Ni, Pb, Zn, and Fe from aqueous solutions. Terrestrial plants are more helpful for rhizofiltration due to their fibrous and much longer root systems.

Advantage of In-Situ Bioremediation

-Eco-Friendly

At its core, bioremediation is a means to eliminate harmful environmental impacts. Unlike excavation-based remediation processes, which can be disruptive, bioremediation is less intrusive and can facilitate remediation of environmental impacts without damaging delicate ecosystems.

-Cost-Effective

Bioremediation can be a highly cost-effective technology. Typically, the cost of treating a hazardous waste site using bioremediation is quite lower than the cost of using conventional treatment methods.

-Scalable

Bioremediation technology is easily scalable, treating a range of areas from
small landfills to massive water treatment plants, For example, sewage treatment plants
are the largest bioremediation enterprise in the world, with approximately 34 billion
gallons of wastewater collected exactly.

Limitations of In-Situ Bioremediation

The major limitation in In-Situ bioremediation is that the sites are directly exposed toenvironmental factors like temperature, oxygen supply etc, along with that the seasonal variation of microbial activity also exists.